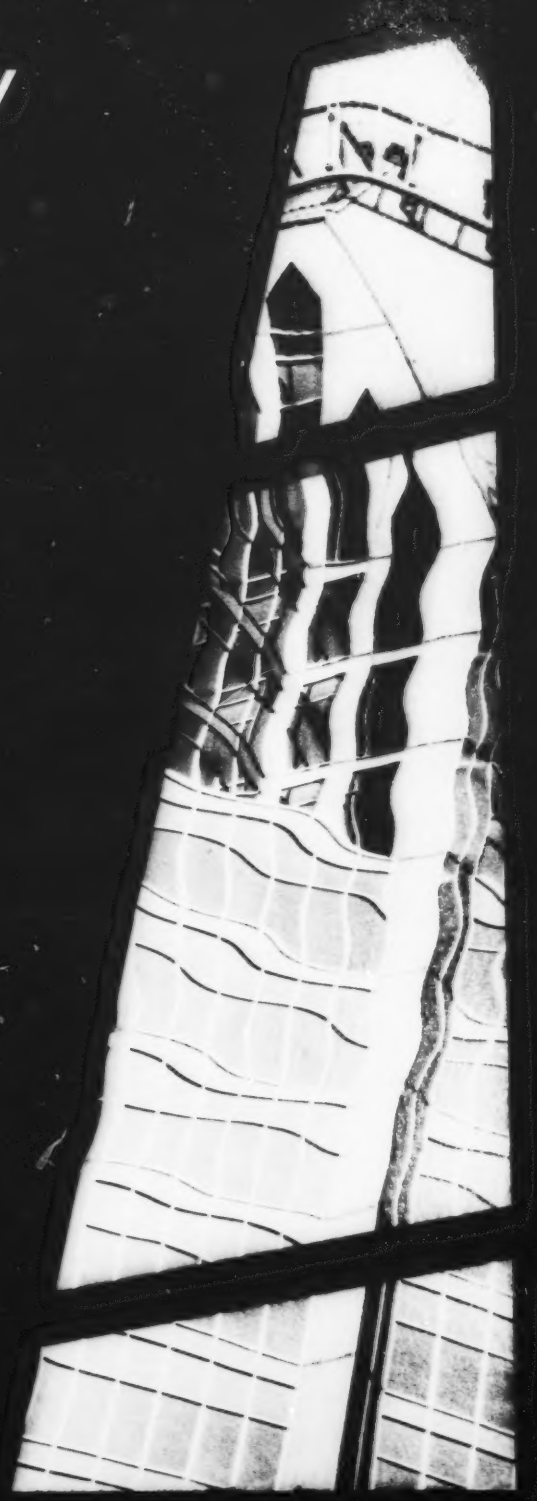
National Research Council Canada | Conseil national de recherches Canada

Institute for Research in Construction | Institut de recherche en construction

NRC·CNRC

Working with the Construction Industry

Research in Action



Canada

CONTENTS

Executive Summary i-iv

Technology in Action:
IRC Collaborations with Industry 1-12

Research Overview:
IRC Research and
Related Activities 13-48

INSTITUTE FOR RESEARCH
IN CONSTRUCTION
National Research Council
of Canada
Montreal Road
Ottawa, Ontario
K1A 0R6
Tel: (613) 993-2607
Fax: (613) 954-5984

© Copyright National Research Council of Canada 1992

About The Institute For Research In Construction

The Institute for Research in Construction (IRC) is a division of the National Research Council of Canada, and is responsible for the Council's Construction Program. With a staff of 250 engineers, scientists, architects, technical experts and administrative staff, IRC operates the Construction Program through its own research and technology development activities and through its strong affiliation with field advisors of NRC's Industrial Research Assistance Program (IRAP).

IRC's mission is to provide Canada's construction industry with the best possible technology. This contributes to the mission of NRC, which is to enhance the socio-economic well-being and competitiveness of the country.

The strategic objectives of IRC are:

- to undertake research of significance to the Canadian construction industry and its users;
- to develop appropriate technology and information and promote their adoption by the industry;
- to support the national construction codes, standards and evaluation systems.

93-00959/

IRC had another banner year as the construction industry's R&D laboratory. The increasing demand for IRC services reflects the industry's strong push for quality and durability. Through partnerships, IRC is assisting industry to develop technologies for high-strength concrete, superior windows, energy-efficient lighting, fire resistance, effective noise control for home and office, and more durable pavement and buried works.

The National Building Code is firmly entrenched as a world model for safe, efficient construction, proof of IRC's value as Canada's code leader. IRC is now assisting the industry to address code requirements for structural and fire safety in building rehabilitation, and to develop an energy code for new buildings.

IRC's materials evaluation service is spurring innovation in construction. Manufacturers now realize they can get a new product into use quickly when it has been shown, through evaluation, to meet the intent of the National Building Code. Evaluation gives building officials the basis to approve a product and designers the confidence to use it.

IRC met, with great success, its mandate to help the industry put research results into action. A cross-Canada seminar on codes and evaluation, a symposium with the Royal Architectural Institute of Canada, and the publication of numerous articles in trade magazines were just a few IRC activities received enthusiastically by practitioners.

CANADIAN CONSTRUCTION INDUSTRY STATISTICS

Value of New Construction (all types)
(Billions of 1990 dollars)

Value of Building Repair and Renovation
(Billions of 1990 dollars)

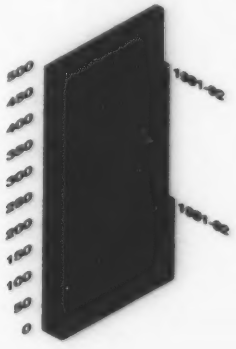
Infrastructure Costs
(Billions of 1990 dollars)

IRC STATISTICS

Energy Use in Canada by Sector, 1990
(Percentage)

Revenue from Contracts and Tests
(Millions of 1991 constant dollars)

Publications and Client Reports
(Number)



Message From The Director General of IRC

The need to make Canadian industry more competitive has become the top priority at the National Research Council. The Institute for Research in Construction (IRC) is the NRC division charged with improving the competitiveness of construction, the country's largest industrial sector.

As this report will testify, IRC is equal to the task. We have organized ourselves in a strategic way. We conduct research of international quality on strategic issues in construction. We discharge NRC's mandate to produce progressive model construction codes and practices. We promote innovation by evaluating novel construction materials. We transmit, through partnerships, the best in technical information from around the world to the industry. Last, but not least, we train engineers and scientists who will enhance Canada's technology culture.

IRC is conscious that in addition to serving the country's largest industry, our work touches the lives of all Canadians. That is why Canada's construction technology source is situated within NRC. You will read in these pages of the comprehensive scope of IRC's programs, an indication of what is demanded of us by you, our clients and stakeholders. We invite your comments and suggestions on how we might better serve.

George Seaden
Director General

May 1992

This section is a summary of IRC collaborations with industry.

IRC has joined forces with several partners to set new standards for high performance windows.

The Institute for Research in Construction (IRC) is a national resource for solving major engineering problems. IRC's value – assisting industry to develop and apply innovations, with an eye on energy conservation and environmental protection – is reflected in its ability to attract national and international partners.

No fewer than five partners are working with IRC to study new compact fluorescent lighting technologies: the Canadian Electrical Association (CEA), Energy, Mines and Resources Canada (EMR), Lawrence Berkeley Laboratory, the U.S. National Institute for Science and Technology, and the U.K.'s Building Research Establishment.

With the best window laboratory in Canada, IRC is hard at work with the Insulating Glass Manufacturers Association of Canada to advance glazing technology. Major partners are Ontario Hydro, the Ontario Ministry of Energy, and EMR.

The creation of an energy code for new buildings is well underway. As the principal research supporter and the publisher of the National Building Code, IRC is the leader in this energy venture.

IRC's assistance to manufacturers faced with the phasing out of ozone-depleting CFC's used in plastic insulations is drawing international recognition. The three-year partnership with the Society of the Plastics Industry has been extended for another three years, with support from both Canadian and American sources.

"Window manufacturers are delighted to work with IRC to improve their products."
Gord Wagner, Operations Manager, Trulite Industries, and Past President, Insulating Glass Manufacturers Association of Canada

While CFC's are an insidious environmental threat, others are more visible, such as fresh concrete waste. IRC's concrete team, working with Mulco Inc., a building product manufacturer and Bétonnières modernes, a division of Asphalte Desjardins, developed a retarding admixture that can be added to concrete mixes, allowing excess product to be left in trucks overnight and reactivated for use the next day.

Saving deteriorating structures also cuts waste. The Canadian Institute of Public Real Estate Companies, representing Canada's largest developers, knows well the damage caused to parking garages by de-icing salts. These companies and three government partners are teaming with IRC to develop repair technologies.

A consortium, represented by the International Lead Zinc Research Organization, and IRC are studying the use of metallized zinc anodes for cathodic protection systems for concrete structures. Various new formulations of shotcrete, used as overlays for cathodic protection, have also been developed.

Microfibres of plentiful minerals, such as wollastonite, are being studied for their potential as additives to increase the strength of concrete for demanding repair applications. Eight Canadian universities and several engineering firms and provincial agencies are collaborating with IRC in this study.

"IRC's concrete experts very quickly helped us to develop a new technology to improve our business."
Claude Bédard,
General Manager,
Admixture Division,
Mulco Inc.

High-strength concrete may perform well under normal conditions, but will it withstand assault by fire? IRC is trying to answer that question in a joint study with the Portland Cement Association of Skokie, Illinois, and the Canadian Portland Cement Association. Full-scale building columns made with high-strength concrete are being subjected to severe fire tests to determine their fire resistance.

The steel industry, through the Canadian Steel Construction Council, is also relying on IRC to determine the fire resistance of hollow steel columns filled with concrete.

Research gives designers safe new options. The application of special sprinklers to protect glazing used in fire-rated separations, developed jointly by IRC and Rolf Jensen and Associates, is being expanded through further testing.

Fire safety also figures prominently in the rehabilitation of buildings, now widespread. Accordingly, IRC has assigned resources to assist industry to address the problem of upgrading fire safety measures in existing buildings to meet National Building Code requirements. This activity is directly related to IRC's mandate to provide technical support to the code.

"IRC's unique column furnace is ideal for full-scale testing under realistic conditions, which is essential for establishing the fire resistance of high-strength concrete." Richard McGrath, Manager, Engineering, Canadian Portland Cement Association

Extending The Life of Pavement

Canada's infrastructure is also in urgent need of rehabilitation. Filling a research void, IRC has established a new program to develop technologies for improving the durability of pavement and the frost-protection of urban infrastructure.

Pavement cracking plagues all road authorities. The City of Montréal and IRC are trying to do something about it by evaluating many types of crack sealers, with the hope of developing an easily applied and durable product. A new laboratory apparatus designed and built by IRC is proving excellent for evaluating the strength of crack repairs.

The effects of cracking and moisture on asphalt pavement is the subject of a collaboration between IRC and the Ontario Ministry of Transportation.

Nova Husky Corporation has contracted with IRC to develop mix designs for asphalt concrete using large aggregate. A revolutionary new compactor, in trials conducted by IRC, has proven capable of compacting mixes with aggregate up to about 6 cm in diameter, a feat unmatched by any commercial roller now in use. These projects offer promise in reducing the problem of rutting, caused by heavy traffic loads.

"IRC is to be commended for undertaking pavement research, which is already paying off for us." Dr. Gerhard Kennepohl, Head, Pavements and Roadway Office, Ontario Ministry of Transportation

Pavement research is not the only way IRC takes to the road. IRC's guiding philosophy is that to effectively help industry to put new research results into use, one must go beyond the laboratory.

Each year for 30 years, practitioners have looked forward to IRC's annual seminar series, Building Science Insight. The Insight team recently visited 14 Canadian cities, explaining codes, standards and evaluation issues.

IRC joined with the Royal Architectural Institute of Canada to sponsor a symposium on post-occupancy evaluation and facility management. To serve other disciplines in construction, IRC contributes dozens of articles to trade magazines.

Canada's biggest building technology gold mine in recent years was surely the 12th World Building Congress, organized by IRC in Montréal in May, 1992. The industry also has direct access to IRC's treasure of construction literature, the best in the western hemisphere. Through it, IRC serves as a major clearinghouse for information on innovations from around the world. As an added service, IRC issues a catalogue of European building publications.

In addition to facilitating the adoption of new technologies, IRC, through its evaluation service, helps manufacturers to innovate. Using a network of industry laboratories, IRC evaluates new materials to ensure their fast acceptance by designers, builders and regulators.

"RAIC is pleased to collaborate with IRC to increase architects' knowledge of technical information vital for improving the performance of buildings."
William Shields,
Executive Director,
Royal Architectural
Institute of Canada

Some Clients and Collaborators

Air Infiltration and Ventilation Centre, U.K.
ASHRAE Inc.
Atomic Energy of Canada Ltd.
Autocon Equipment Ltd.
BASF Canada, Inc.
B.C. Housing Management Commission
B.C. Hydro
Bell Northern Research Ltd.
BNI Systems
British Research Establishment, U.K.
Calgary Winter Club
Canada Mortgage and Housing Corporation
Canadian Electrical Association
Canadian Home Builders' Association
Canadian Institute of Public Real Estate Companies
Canadian Pacific Hotel Corporation
Canadian Portland Cement Association
Canadian Standards Association
Canadian Steel Construction Council
Canadian Wood Council
Carleton University
Celfortec
Ciment d'isolation thermique
City of Calgary
City of Edmonton
City of Montréal
City of Vancouver
City Polytechnic of Hong Kong
Consolidated Concrete
Decoustics Limited
Department of National Defence
Dow Canada
Du Pont Canada Inc.
Electric Power Research Institute, U.S.
Energy, Mines and Resources Canada
FEKAB Inc. (Ottawa)
Fiberglas Canada Inc.
Forintek Canada Corporation
G.K. Yuill & Associates
General Electric Co.
Golder Associates
Griffiths Rankin Cook - Architects
Holderbank Management Consulting Ltd.
Hydro-Québec
IBM Canada Ltd.
IKO Industries Ltd.
Indal Wall Systems
Insulating Glass Manufacturers Association of Canada
International Development Research Centre
Isover, St. Gobain, France
J.R. Paine Consultants
Kajima Corporation of Japan
Lafarge Canada Inc.
Lovat Tunnelling Equipment, Inc.
Lupien Rosenberg Assoc. Ltée
M.J.M. Conseillers en Acoustique
Matériaux Cascades Inc.
Monenco Consultants Ltd.
Mulco
National Arts Centre
National Association of Forest Industries, Australia
National Physical Laboratories, U.K.
National Testing Laboratories
Nickel Development Institute
Nova Husky Research Corporation
Ontario Home Builders Association
Ontario Hydro
Ontario Ministry of Energy
Ontario Ministry of Housing
Ontario Ministry of Transportation
Ottawa Fibre
Plastiglas Industries Ltd.
Portland Cement Association, U.S.
Potash Corporation of Saskatchewan Inc.
Precision Manufacturing Inc.
Public Works Canada
Quebec Ministry of Transport
Read Jones Christoffersen
Reflectix
Regional Municipality of Ottawa-Carleton
RILEM
Rolf Jensen and Associates Ltd.
Simpson Gumpertz Heger
Slovak Technical University
Society of Plastics Industry of Canada
Soundfield Acoustics Systems
Stadium Corporation of Ontario Ltd.
Standards Council of Canada
Stone and Webster
Taisei Corporation of Japan
Technical Research Centre of Finland
TREMCO Canada
TROW Ontario Ltd.
Trulite Industries
Underwriters' Laboratories of Canada
Unilever Research
Université Laval
Westroc Industries

CONTENTS

The Building Envelope	14
The Indoor Environment	18
High-Performance Construction Materials	22
Fire Safety	26
Safety and Serviceability of Structures	30
Durability of Roadways	34
Infrastructure for Cold Climates	36
National Building and Fire Codes	38
Materials Evaluation	40
Industry Liaison	42
Recent Publications	44

Building envelope research at IRC focuses on the transport of heat, air, moisture and sound through materials, components and systems used in building envelopes.

OBJECTIVES

- To develop knowledge, techniques and information on the control of heat, air, moisture and sound transport across building envelopes
- To provide the technical foundation for the design, construction, commissioning and operation of building envelopes to meet the requirements of thermal, acoustic and moisture performance and durability
- To transform research results into practical information, including codes and standards

HEAT, AIR AND MOISTURE

IRC has developed a method for determining the moisture transport properties of materials. A model for examining the simultaneous transport of heat, air and moisture, developed with VTT, Finland, is being used to study individual building materials, as well as the performance of complete envelope systems. This is leading to guidelines for designing building envelopes free of harmful moisture accumulation.

IRC supports the Canada-U.S. project on the evaluation of high-performance windows. In addition, researchers have begun a three-year project on durability of high-performance sealed glazing units. Commercial demand for the IRC R-value test procedure for windows is expected to remain high until commercial laboratories gear up to perform the recently approved ASTM version of the procedure.

A procedure to evaluate the pressure-equalization performance of rainscreen walls developed by IRC has been used to evaluate the performance of both a prefabricated brick wall system and a metal and glass system. A model to simulate performance is being created.

Envelope research is increasingly driven by environmental concerns. In a joint three-year research program with plastics manufacturers, IRC developed models for predicting the long-term thermal and moisture performance of gas-filled insulation materials with low ozone-depletion potential. This program has now been extended until 1995.

Work is proceeding on an energy code for buildings, stemming from concerns about global warming. IRC is providing the research and technical support.

IRC's Acoustics Laboratory and Building Performance Laboratory work together to help the construction industry improve the performance of building envelopes.

RECENT ACHIEVEMENTS

- Used the IRC/VTT model to develop guidelines for rehabilitation of a heritage building envelope, as well as to examine the requirement for vapour retarders in residential wall systems
- Obtained, experimentally, moisture transport properties of common building materials (brick and pine)
- Applied two new quality control apparatuses and procedures, in a round robin project, to expanded polystyrene products
- Completed the extended evaluation of sprayed polyurethane foam made with non-ozone-depleting blowing agents and began evaluating board stock
- Developed a procedure for testing air leakage of windows under specified temperature and pressure differentials
- Led a Canada-U.S. research team to develop and verify standard

IRC is leading the development of a building energy code in response to increasing demands on electrical generation and global warming related to carbon dioxide emissions.

calculations and test methods to determine the R-value of high-performance window systems
- Began a study of the long-term durability of insulating glass units and window assemblies
- Conducted a field evaluation of brick veneer/steel stud walls
- Evaluated the air barrier system and the pressure-equalization performance of a metal and glass curtain wall
- Developed a laboratory procedure to measure the dynamic thermal performance of walls and drafted a standard ASTM procedure
- Developed a framework for the proposed building energy code

PLANS

- Improve the heat and moisture model and apply it to envelope systems in Canadian climatic conditions
- Extend the moisture transport model to three-dimensional cases
- Develop and apply the methodology for evaluating board stock plastic insulation
- Complete a model for pressure-equalized rainscreen walls
- Upgrade the dynamic wall test facility and procedure and evaluate the air leakage and rain penetration control of specimens under wind loading
- Determine heat loss factors for innovative basement insulation strategies and develop guidelines for avoiding basement condensation
- Develop a procedure to measure the performance of air barrier systems under temperature differentials
- Complete a thermal resistance comparison between IRC's new standard guarded hot plate apparatus and European and ISO standards
- Develop and implement strategies to evaluate the energy code

SOUND TRANSMISSION

Sound transmission research applies to both the exterior envelope and interior walls and floors. It helps industry to develop cost-effective ways of controlling sound transmission; improves field and laboratory procedures for measuring sound transmission; and combines objective measurements of sound with evaluations of human reaction.

The control of low-frequency noise is a major problem in practice. IRC's acoustics instrumentation and facilities have been substantially upgraded, and measurement procedures have been extended, to improve precision and obtain data for extending standard test methods to lower frequencies. The plan is to assemble a large edited database of reliable data on sound transmission through common generic wall and floor constructions.

Studies of noise control in offices have included systematic evaluation of factors limiting the performance of typical partition/suspended ceiling systems and the development of practical strategies to improve sound insulation without seriously impeding ventilation. Sound generated by, or transmitted through, ventilation systems is another concern.

RECENT ACHIEVEMENTS

- Constructed a chamber for measuring sound transmission through floors
- Completed a study to assess methods for rating impact noise transmission through floors, using conventional and

prototype impactors, including the Japanese tire-drop method
- Studied sound transmission through walls of non-standard (slotted or porous) concrete block with drywall surface treatments
- Evaluated cross-talk between offices via air-supply duct systems
- Applied digital signal processing techniques with a pseudo-random sound source to develop a prototype for sound transmission measurements in offices, with signal levels similar to the ambient sound

PLANS

- Study sound transmission through drywall partitions, including the effect of cavity absorption and drywall type, for a wide range of wall constructions
- Commission the facility to measure sound transmission through floors
- Construct and commission a new facility for measuring sound transmission through coupled floor/wall systems (flanking sound)
- Study flanking transmission in wood-frame walls and floors
- Participate in developing codes and technical standards for assessing the audibility of fire alarms
- Evaluate community-response studies and noise-prediction procedures for noise exposure near major airports

RESEARCH TEAMS

HEAT, AIR AND MOISTURE

Eric Aspila, B.A.
Sherif A. Barakat, B.Sc., M.Sc., Ph.D. (Laboratory Head)
Appupillai Baskaran, B.Sc., M.Sc., Ph.D.
Mark Bomberg, M.Eng., D.Sc.(Eng.), Dr. Techn.
William C. Brown, B.Eng., M.Sc.
A. Hakim Elmahdy, B.Sc., M.Sc., Ph.D., M.B.A.
Achilles Karagiozis, B.Sc., M.Sc., Ph.D.
J. Gareth Keatley
M. Kumar Kumaran, B.Sc., M.Sc., Ph.D.
John Lackey
Roger G. Marchand, B.Sc.
Nicole Normandin
Gilles F. Poirier, B.Sc.
Clifford J. Shirtliffe, B.Sc., M.Sc.
Michael C. Swinton, B.Sc., M.Sc.
Jim Ulett, B.Sc.

SOUND TRANSMISSION

John S. Bradley, B.Sc., M.Sc., Ph.D.
Wing T. Chu, B.A.Sc., M.A.Sc., Ph.D.
Maria Clancy
Brian O. Fitzpatrick
Robin E. Halliwell, B.A.Sc., M.A.Sc., Ph.D.
Ed C. Luctkar
Jacques Pierre, B.Eng.
J. David Quirt, B.Sc., Ph.D. (Laboratory Head)
Alf C.C. Warnock, B.Sc., Ph.D.

CONTACTS

Building Performance Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-9580
Fax: (613) 954-3733

Acoustics Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-2305
Fax: (613) 954-5984

IRC's new facility for research on sound transmission will greatly enhance technology development for noise control.

IRC's Indoor Environment research provides the construction industry with the knowledge and tools needed to design and operate indoor environments in a wide variety of settings, from office buildings to concert halls.

OBJECTIVES

- To relate occupant reactions to the physical attributes of the indoor environment
- To develop analytical models for the design of indoor environments
- To develop measurement systems for evaluating specific physical characteristics of the indoor environment and practical analysis protocols for gauging occupant reactions
- To transform research information into forms appropriate for the construction industry, including building codes and standards

IRC focuses on three critical elements of indoor environment performance — lighting, ventilation and indoor air quality, and acoustics. The goal is cost-effective technology to properly control these three elements and maximize the safety, productivity and satisfaction of occupants.

LIGHTING

Recently, IRC lighting researchers have been evaluating the performance of several new lighting technologies that are attractive because of their more efficient operation and lower costs.

They are currently developing a lighting analysis protocol that relates information provided by previously developed evaluation tools to occupant satisfaction. Studies in the subjective reactions laboratory will translate into designs for space illumination that enhances occupant satisfaction and productivity.

Practical information on the performance of fluorescent lighting systems will be provided to utilities and users.

A study of emergency lighting systems conducted in large office buildings revealed a need to improve safety by ensuring that occupants easily find exits during conditions of poor visibility.

IRC is evaluating innovative lighting technologies with regard to occupant satisfaction and energy efficiency.

RECENT ACHIEVEMENTS

- Completed experiments on the effects of spatial distribution and intensity of light on impressions of brightness
- Completed a lighting evaluation protocol, including survey techniques and measurement systems, to assess the quality of light and occupant satisfaction in office buildings
- Evaluated the performance of energy-efficient fluorescent lighting systems
- Developed a method of performing emergency lighting surveys using the CapCalc video photometer
- Conducted a survey of emergency lighting systems in large buildings and provided guidelines for improvement

PLANS

- Complete the evaluation of compact fluorescent energy-efficient lighting systems
- Deliver a cross-Canada series of one-day seminars on lighting, including the results from subjective evaluations
- Recommend improvements in regulations for exit signs and emergency lighting systems
- Complete a report on lighting quality guidelines for office environments

- Complete a study on energy consumption by desktop computers and develop strategies and technologies to reduce their energy use

An understanding of air movement patterns, achieved through a combination of analytical modelling and experiments, is vital to achieving good thermal comfort and indoor air quality.

VENTILATION AND INDOOR AIR QUALITY

Good performance of the HVAC system is crucial to an acceptable indoor environment. IRC is developing facilities and tools to predict and monitor the behaviour of HVAC systems; these include a ventilation test house, also useful for evaluating new products.

Techniques to measure interior air flow patterns, air change rates and ventilation effectiveness are being developed and simplified for use by practitioners.

IRC is extending its expertise in contaminant measurements, especially volatile organic compounds found in the air of Canadian buildings.

Research in the subjective reactions laboratory will study occupant reactions to various ventilation and indoor air quality factors.

RECENT ACHIEVEMENTS

- Developed procedures to assess air change rate and indoor air quality in large buildings, based on CO_2 measurements
- Completed a study of the change in overall airtightness of tall buildings due to aging and retrofits
- Established laboratory protocols for assessing ventilation efficiency for work stations
- Created the modelling capability for analyzing room air flows and contaminant distribution

PLANS

- Establish field and laboratory protocols for assessing indoor air quality
- Apply computational fluid dynamic (CFD) based air-flow models for assessing ventilation systems and indoor air quality
- Assess ventilation strategies for houses
- Establish bases for using CO_2 for ventilation control in office buildings

ROOM ACOUSTICS

Room acoustics research at IRC assesses the sound in all kinds of rooms, from offices and classrooms to factories and large auditoriums. The program has three elements: relating people's reactions to sound from specific sources or to the characteristics of the space; developing tools (from computer models to simple algorithms) to predict performance at the design stage; and developing measurement techniques and prototype equipment to evaluate the performance of existing spaces or noise sources.

The assessment of existing spaces includes both commissioning of new spaces and renovation of unsatisfactory spaces. Measurement techniques and knowledge gained from evaluation of major concert halls throughout the world, apply also to evaluation of speech quality in conference rooms. In both cases, the architectural features relate to the sound field characteristics. Noise control in industrial spaces or offices uses the same basic concepts and tools, with some adaptation.

RECENT ACHIEVEMENTS

- Improved the acoustic assessment of auditoriums by developing an enhanced room acoustic measurement system using digital signal processing techniques with a pseudo-random sound source, and demonstrating its application in concert halls and auditoriums, including measurements with an audience present
- Evaluated characteristics of the monaural sound field in small rooms necessary for excellent speech quality
- Completed studies of noise emission from residential ventilation fans and air conditioners
- Performed a major experimental study to evaluate the precision of sound power measurement in reverberation rooms for rating low-frequency sound emission from HVAC systems

PLANS

- Coordinate an international comparative study of acoustics of major performing arts halls in North America
- Develop technical criteria for instrumentation for standard methods of assessing room acoustics
- Assemble room response data and a system for auditory simulation of room effects for a collaborative study of binaural effects in judgments of speech quality
- Commission a new room acoustics facility for fundamental studies of sound fields in rooms and for standard testing of office acoustics

RESEARCH TEAMS

LIGHTING AND VENTILATION

Sherif A. Barakat, B.Sc., M.Sc., Ph.D. (Laboratory Head)
Ralston R. Jaekel
Robert J. Magee, B.Sc., M.E.Sc.
Guy R. Newsham, B.Sc., Ph.D.
Michael J. Ouellette, B.Sc.
James T. Reardon, B.Sc., M.A.Sc., Ph.D.
M. Nady Said, B.Sc., M.Sc., Ph.D.
Daniel M. Sander, B.Eng., M.Sc.
C.Y. (John) Shaw, B.Sc., M.Sc., Ph.D.
Jana Svec, B.Sc.
Dale K. Tiller, B.A., D.Phil.
Jennifer A. Veitch, B.Sc., M.A., Ph.D.
Joanne Wathier
Juergen Weichert, B.Sc.
Jianshun Zhang, B.Sc., M.Sc., Ph.D.

ROOM ACOUSTICS

Jennifer Birta, B.Eng.
John S. Bradley, B.Sc., M.Sc., Ph.D.
Wing T. Chu, B.A.Sc., M.A.Sc., Ph.D.
Maria Clancy
Brian O. Fitzpatrick
Robin E. Halliwell, B.A.Sc., M.A.Sc., Ph.D.
Jacques Pierre, B.Eng.
J. David Quirt, B.Sc., Ph.D. (Laboratory Head)

CONTACTS

Building Performance Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada, K1A 0R6
Telephone: (613) 993-9580
Fax: (613) 954-3733

Acoustics Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada, K1A 0R6
Telephone: (613) 993-2305
Fax: (613) 954-5984

IRC develops methods to measure sound emission from common sources, and compares these ratings to sound levels in real situations.

IRC's Materials Laboratory carries out research to improve the performance of inorganic, polymeric and composite materials for new construction and renovation and repair. Researchers also contribute to codes and standards, assist industry to develop new products, test methods and uses for known materials, and assess materials and systems on site and in the laboratory.

OBJECTIVES

- To develop new laboratory and field test methods to predict and evaluate the performance and durability of concrete and masonry materials, adhesives, sealants, coatings, and composite repair materials
- To develop and evaluate advanced composites, new admixtures, and roofing, waterproofing and repair materials, and to produce criteria for assessing their performance and durability
- To advise industry, standards-writing groups and the Canadian Construction Materials Centre on the technical assessment of concrete-based, masonry and polymeric materials

Materials research in the 1990's is strongly influenced by environmental concerns, including management of construction and nuclear waste, energy conservation, and the pressing need to repair and rehabilitate aging buildings and a decaying infrastructure. Researchers are working on new strategies for recycling wastes, such as slags, fly ash, crushed limestone and silica fume, more effectively in concrete.

Durability will be increasingly factored into the design process, and high-performance repair materials for concrete will become the standard. Data collected in a survey of 70 salt-damaged parking garages is proving useful in developing repair strategies.

Infrastructure renewal requires new cement-based materials and novel compositions for sealants, adhesives, roofing materials and membranes. A number of different crack-sealing materials for pavement are being tested in the field.

Materials researchers are active internationally, assisting the economies of the Ivory Coast, Egypt and Costa Rica to develop construction products using indigenous materials.

The IRC Materials Laboratory studies composite materials including hybrid systems, admixture interactions in cement systems, organic-inorganic material systems, physico-mechanical material behaviour, and materials chemistry.

IRC materials researchers apply a combination of thermoanalytical, spectroscopic and engineering techniques to predict the durability of polymeric roofing materials.

RECENT ACHIEVEMENTS

- Developed a new admixture for recycling concrete waste
- Elucidated mechanisms of superretarding action of organic concrete admixtures
- Developed new high-strength cement composites containing inorganic microfibres for repair purposes
- Studied the interactions of accelerating and retarding admixtures with cement phases
- Developed new techniques, based on AC impedance spectroscopy, for characterizing microstructure of cement-based repair materials
- Completed a five-year study of the behaviour of silica fume in concrete
- Established new methods of eliminating external corrosion on pipelines
- Improved the adhesion of zinc-flame sprayed coatings to concrete for cathodic protection
- Developed new shotcreting formulations for overlays on cathodic protection systems
- Developed an expert system for sealant selection, for use by non-experts
- Completed a three-year study of the freeze-thaw durability of clay brick

PLANS

- Begin a study of the durability of high-volume fly-ash concrete
- Continue research on high-performance cement composites incorporating wollastonite microfibres
- Study porous particulate systems for preventing freeze-thaw damage to concrete
- Initiate research on anti-freezing admixtures in concrete
- Continue thermal analysis of roofing membranes
- Initiate work on the correlation between natural and artificial weathering of polymeric construction materials
- Develop new test methods for sealants

RESEARCH TEAM

Mark Arnott, B.Eng.
James J. Beaudoin, B.A.Sc., M.A.Sc., Ph.D., F.A.C.S. (Laboratory Head)
Réjean J. Brousseau, B.Sc., Ph.D.
Gordon W. Chan
Doreen G. Charron
Peter G. Collins, B.Sc.
Ana H. Delgado, B.Sc., M.Sc.
Om Dutt, B.A., B.Sc., M.S., Ph.D.
Rolf F. Feldman, B.Sc., Dipl. Chem. Tech., M.A.Sc., D.Sc., F.A.C.S.
Paddy E. Grattan-Bellew, B.Sc., M.Sc., Ph.D.
Jocelyn P. Henrie
Michael A. Lacasse, B.Sc., M.Eng., Ph.D.
William Lei, B.A.Sc.
Gerard G. Litvan, Dipl. Chem., Ph.D., F.A.C.S., F.C.I.C., Principal Research Officer

Mark Lowery, B.Sc.
Noel P. Mailvaganam, B.Sc., M.Sc., C.Chem.
James C. Margeson, B.Sc.
Jean-François Masson, B.Sc., Ph.D.
Garry W. Mould
Robert E. Myers
Montha Nguon, B.Sc.
Ralph M. Paroli, D.E.C., B.Sc., Ph.D.
Garry M. Polomark
Glendon Pye, B.A.Sc., M.A.Sc.
Ed G. Quinn
V.S. (Ramu) Ramachandran, B.Sc., M.Sc., C.Chem., Ph.D., D.Sc., D.Sc. (Hon.), F.R.S.C., F.A.C.S., F.I. Ceram., Principal Research Officer, IRC Distinguished Researcher
Herman Schultz
Margaret Thomson, B.Sc., Ph.D.
Peter Tumidajski, B.A.Sc., M.A.Sc., Ph.D.

IRC carries out vital research on the durability and protection of concrete against corrosion and alkali-aggregate reaction.

CONTACT

Materials Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-1596
Fax: (613) 954-5984

The mandate of IRC's Fire Safety research, conducted by the National Fire Laboratory (NFL), is to reduce the burden of fire in Canada and to assist the Canadian construction industry with its fire safety needs through research, technology transfer and technical support for the National Building Code and the National Fire Code. The burden of fire is defined as loss of life, property and function, and the cost of fire safety technology.

OBJECTIVES

- To develop the analytical and experimental methods required to solve technical problems in fire safety and code compliance for the rehabilitation of buildings
- To develop strategic technologies and assessment methods that address the major fire safety issues of the National Building Code as related to new construction
- To develop a comprehensive risk-cost model and supporting fire models for assessing risks and protection costs in apartment and office buildings

With rehabilitation projects, a major problem has been the lack of prescriptive or performance measures to develop cost-effective fire safety alternatives to code requirements. To counter this problem, the NFL is studying sprinkler systems, smoke control, structural fire safety and hazard assessment.

For new construction, the high cost of achieving fire protection and the lack of flexibility for meeting code requirements have plagued designers. The NFL is addressing these problems through research on structural fire protection materials and methods, extinguishing systems, fire resistance based on building size, and spatial separations.

In risk and cost assessment, the NFL is concentrating on improving and validating the models developed recently for highrise residential and office buildings. This work is in collaboration with experts from Australia. In due course, the research will be extended to cover hospitals, hotels and mercantile buildings.

RECENT ACHIEVEMENTS

- Completed a mathematical model for calculating the fire resistance of concrete slab-beam assemblies and constructed full-scale test specimens
- Completed full-scale experiments on glass assemblies exposed to room fires. Prepared, for the Underwriters Laboratories of Canada, a draft standard for testing such assemblies
- Completed, in collaboration with Forintek Canada Corporation, a mathematical model for heat transfer through wood-frame walls protected by gypsum board
- Constructed a full-scale room calorimeter fire-testing facility and completed nine experiments for ASHRAE as part of a joint research project on smoke movement under sprinklered conditions

IRC has a full range of excellent fire research facilities, such as a 10-storey tower for smoke-control studies, a huge burn hall for full-scale fire tests, a column furnace for fire-resistance tests, and instrumentation for fire-gas analysis.

IRC is assisting the construction industry to address fire safety issues encountered in the rehabilitation of buildings.

- Completed fire and non-fire tests for stair vestibule pressurization as validation for NBC Measure "H" on Fully Pressurized Buildings
- Commenced a joint research project with the Department of National Defence to study the use of fine watersprays for extinguishing fires
- Completed the development of one-zone fire growth models for apartment buildings including three design fires, door open and closed conditions, and window intact and broken conditions. This is the first model of its type, and has been incorporated into a risk-cost assessment model.

PLANS

- Begin studies of compartment fires to assess degrees of combustibility
- Develop with VTT, Finland, a model for predicting the fire resistance of reinforced concrete-filled steel columns
- Identify reliable fire detection/water spray actuation technologies for use with fine waterspray systems
- Complete the testing of slab-beam assemblies and validate models for the prediction of fire resistance
- Complete fire-resistance models for wood-frame walls with Forintek Canada and begin incorporating these in the risk-cost model
- Complete a model of contour protection for fire resistance of wide-flange steel columns
- Develop a model for fire plumes issuing from windows
- Conduct large-scale radiant ignition tests on exterior walls
- Complete the risk-cost model for the renovation of office buildings in a joint project with Public Works Canada
- Complete research with the Portland Cement Association and the Canadian Portland Cement Association on the fire resistance of high-strength concrete columns
- Conduct full-scale fire experiments on fine waterspray systems in ship machinery rooms and begin development of a mathemtical model
- Complete the risk-cost assessment model for apartment buildings in joint research with the National Association of Forest Industries, Australia

RESEARCH TEAM

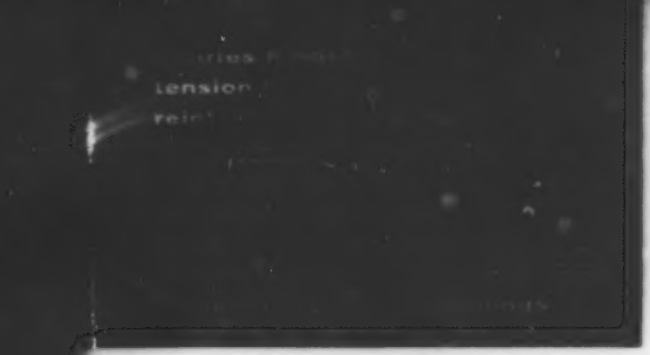
D. Elizabeth Anderson
Donald W. Carpenter
George P. Crampton
Victor A. Fortington
George V. Hadjisophocleous, B.Sc., M.Sc., Ph.D.
J. Malgosia Kanabus-Kaminska, M.Sc.(Chem.), M.Sc. (Chem. Eng.), Ph.D.
Andrew K. Kim, B.A.Sc., M.A.Sc., Ph.D.
John C. Latour
T.T. Lie, Dipl. Ing., Principal Research Officer

Gary D. Lougheed, B.Sc., M.Sc., Ph.D.
Robert A. MacDonald
John W. MacLaurin
Jacques F. Mathieu
Jack R. Mawhinney, B.Eng., M.Eng.
Roch C. Monette
Donald W. Morwick
J. Kenneth Richardson, B.Sc., B.Eng.
(Laboratory Head)
Mohamed A. Sultan, B.Sc., M.Sc., Ph.D.
Bruce C. Taber
Hisa Takeda, B.Sc., M.Sc., Ph.D.
George Tamura, B.Sc.
Yoshio Tsuchiya, B.Eng., Dr.Eng.
David Yung, B.Eng., M.A.Sc., Ph.D.

IRC's fire research activities include both full-scale and small-scale studies, as well as computer modelling.

CONTACT

National Fire Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-2204
Fax: (613) 954-0483



The IRC Structures Laboratory provides the construction industry with technologies and evaluation criteria it needs for the rehabilitation and structural durability of buildings.

OBJECTIVES

- To develop criteria and methods for structural evaluation, repair and upgrading of existing buildings
- To develop durability criteria for the design of new buildings and rehabilitation of existing ones
- To transfer to the construction industry the knowledge developed on rehabilitation and durability in the form of guidelines and improved codes and standards

Rehabilitation is becoming more and more important; Canada's building stock is aging, and environmental and economic considerations favour repair and upgrading over demolition and replacement. Currently, structural rehabilitation follows the criteria and the same codes and standards intended for new buildings. This often leads to unnecessary expense and to construction difficulties, especially with heritage buildings, which must be upgraded without destroying their heritage value.

Structural durability has not been explicitly covered by codes and standards for the design of new buildings. This has led to serious deterioration of parking garages and building facades.

IRC structures researchers are expert in limit states design principles, structural loads, analytical and experimental methods of structural analysis, structural behaviour of building materials, seismic engineering, and structural and soil dynamics. Complementary expertise on materials durability is provided by IRC's Materials Laboratory and on the building envelope by the Building Performance Laboratory.

RECENT ACHIEVEMENTS

- Developed limit states design and load factors for evaluating existing buildings, which should reduce the amount of upgrading required in some buildings
- Drafted guidelines entitled "Application of National Building Code Part 4 to Existing Buildings," of great practical use to designers and regulators
- Completed a study on earthquake performance of masonry buildings and published a report highlighting the need for a better understanding of the response of unreinforced masonry buildings to earthquake forces
- Developed a knowledge-based computer program to identify liquefaction potential of soils subject to earthquakes, for foundation design in seismic risk areas

IRC structures researchers combine laboratory work with field studies to evaluate seismic risks, durability problems and rehabilitation strategies.

The dollar value of building rehabilitation now exceeds the value of new construction.

- Drafted guidelines for the systematic evaluation of seismic hazards in existing buildings
- Completed work on damping devices and upgrading of a steel joist floor system to reduce floor vibrations caused by walking
- Evaluated the dynamic behavior of a new seismically designed 735-kV series capacitor platform as a verification of the design
- Prepared a review of the corrosion resistance of metal components in masonry cladding
- Conducted pilot tests on the effect of corrosion on punching shear capacity of concrete slabs; the tests showed a strong relationship between shear strength and degradation of the steel
- Upgraded the Laboratory's dynamic wall-testing facility to permit testing of a much larger variety of wall constructions, including rainscreen walls

PLANS

- Continue the development of criteria for rehabilitation and durability assessments
- Develop methods to assess residual capacity of deteriorated concrete slabs
- Assess the suitability of fibre-reinforced plastic bars for reinforcing concrete slabs, and follow with load tests on slabs
- Conduct research to determine how the addition of insulation to the interior of masonry walls affects durability
- Determine the factors that influence the durability of masonry ties
- Publish guidelines for the seismic evaluation of existing buildings
- Publish a rapid screening method for seismic adequacy
- Review the seismic behaviour of thick masonry
- Develop simple, non-destructive testing procedures to determine the physical and mechanical properties of masonry walls
- Develop guidelines for trenches for reducing traffic-induced vibrations
- Develop a surface wave testing method to determine soil properties for predicting traffic-induced vibrations

RESEARCH TEAM

M. Osama Al-Hunaidi, B.Eng., M.Eng., Ph.D.
David E. Allen, B.Sc., M.A.Sc., Ph.D.
Y. Lin Cao, B.Eng., M.Eng., Ph.D.
Samir E. Chidiac, B.Eng., M.Eng., Ph.D.
W. Alan Dalgliesh, B.Sc.Eng., M.Eng.
Lise Dessureault
Rock Glazer
Dan Guenter
Wei Guan, B.Sc., M.Sc.
Ted J. Hoogeveen
Charles Kingsley, B.A.Sc.
Andy Laberge
Jeff P. Marans, B.Sc.
A.H. Paul Maurenbrecher, B.Sc., Ph.D.
Gerry Pernica, B.A.Sc., M.A.Sc., Ph.D.
A. Habib Rahman, B.Sc.Eng., M.Sc.Eng., Ph.D.
J. Hans Rainer, B.A.Sc., M.S., Ph.D. (Laboratory Head)
Don A. Taylor, B.A.Sc., M.A.Sc., Ph.D.

IRC has done a preliminary evaluation of the effect of corrosion on punching shear capacity of concrete slabs.

CONTACT

Structures Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-2433
Fax: (613) 954-5984

The goal of IRC's roadways project is to develop technology to prolong the service life of pavement in Canada.

OBJECTIVES

- To improve currently used rehabilitation techniques for pavement and develop innovative solutions
- To develop premium pavements based on modern design, new engineered materials and innovative technology
- To develop new methods for utilizing waste products in pavement

Current expenditures on Canada's roads are $6-8 billion a year. Provinces spend 60-70% of their road budgets on pavement rehabilitation and reconstruction.

IRC is committed to a major research role to improve Canada's road network. Rehabilitation research centres on cold-temperature cracking, rutting, frost heave and moisture damage. Accelerated laboratory techniques are needed, such as IRC's new pavement-testing apparatus.

For new construction, there will be emphasis on pavements with a life of 25-40 years. Stone mastic asphalt, large-aggregate mixes and polymer-modified asphalts will be studied. Efforts to improve compaction will continue.

RECENT ACHIEVEMENTS

- Confirmed the superior performance of a new pavement roller (AMIR) in side-by-side tests with a conventional roller
- Compacted trial sections of large-aggregate and geogrid-reinforced pavement to demonstrate possible solutions to rutting and cracking
- Demonstrated a non-destructive testing technique to determine stratigraphy below pavement
- Completed a study to identify some major causes of pavement distress
- Studied concepts for stone mastic asphalt and large-aggregate mixes combined with modified asphalts

PLANS

- Develop methods of incorporating waste rubber in asphalt pavement
- Evaluate the potential of AMIR for roller-compacted concrete
- Establish a basis for an evaluation procedure for predicting stripping susceptibility of asphalt mixtures
- Seek links with European laboratories to test stone mastic asphalt and large-aggregate asphalt concrete
- Conduct trials on geogrids to control cracking due to pavement widening

RESEARCH TEAM

Bill Bekking, C.E. Tech., B.Sc.
Dave Eldred
Mario Gervais, B.Sc.
Norma E. Hardy
Hozayen Hozayen, B.Sc., M.Sc., Ph.D.
E.H. Hassan Mohammed, B.Sc., M.S.C.E., Ph.D.
J.H. LaVerne Palmer, B.A.Sc., M.A.Sc., Ph.D. (Laboratory Head)
Otto J. Svec, Dipl. Ing., Ph.D.

CONTACT

Infrastructure Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-1466
Fax: (613) 954-5984

IRC researchers collaborate with industry on laboratory studies and field trials to realistically evaluate the performance of new and repaired pavement.

IRC research on infrastructure for cold climates aims to develop innovative cost-effective technologies for the repair and new construction of urban streets, sewer lines and water-distribution systems.

OBJECTIVES

- To develop and evaluate new designs, materials and innovative construction methods to mitigate the effects of cold climate on infrastructure
- To develop fundamental information regarding the behaviour and properties of soils and infrastructure materials and their interaction under freezing and thawing conditions

Canada's water-distribution and sewage-collection systems, streets and sidewalks are seriously deteriorating. Massive expenditures are needed to repair and renovate them. In other cases, replacement is the only option.

Frost action and the annual freezing and thawing of surficial soil cause water lines to freeze and burst, and roadways, sidewalks and manhole covers to heave differentially. To reduce maintenance costs and prolong service life, research is focused on cold-climate effects.

RECENT ACHIEVEMENTS

- Validated the use of insulation to cut the burial depth of watermains in western Canada to less than two metres
- Undertook modelling of buried PVC pipe to evaluate frost penetration and pipe freeze-up during western winters
- Completed evaluations in northern Quebec on "variable thermal conductivity" passive insulation for embankments on permafrost, and on the application of chilled foundations

PLANS

- Initiate a laboratory study of frost-related loadings on buried pipes
- Undertake a study of the thermal and mechanical properties of PVC pipe under freezing conditions
- Construct a sidewalk field test site to measure frost-heave parameters with remote monitoring equipment
- Monitor the performance of the installations in northern Quebec
- Develop innovative techniques to use waste materials as insulation for in-ground applications
- Work with the City of Montréal to study a proposed heat pump/latent heat storage technology for melting snow on sidewalks

RESEARCH TEAM

T. Harry W. Baker, B.Sc., M.Sc.
Don Clerk, B.Eng.
Bill G. Cooke
James R. Crawford, B.Sc.
Lyne D. Daigle, B.Sc.
Dave Eldred
Laurel E. Goodrich, B.Sc., M.Sc., Ph.D.
J.H. LaVerne Palmer, B.A.Sc., M.A.Sc., Ph.D. (Laboratory Head)
Keyvan Sepehr, B.Sc., M.Sc., Ph.D.
Otto J. Svec, Dipl. Ing., Ph.D.
Les White, B.E.S., B.A. (Geogr.), M.Sc.

CONTACT

Infrastructure Laboratory
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-1466
Fax: (613) 954-5984

IRC employs data-logging equipment, cold rooms for scale-model testing, and numerical studies to assess the loads generated on waterlines during trench freezing and to evaluate insulating materials for subgrade use.

The Canadian Codes Centre assists the Canadian Commission on Building and Fire Codes (CCBFC) to develop model codes to encourage the efficient construction of safe and durable buildings. The Centre also serves as the technical interface between research organizations and the committees developing the codes. These codes are published under the authority of the National Research Council and include the National Building Code (NBC), National Fire Code, Canadian Plumbing Code, Canadian Housing Code and Canadian Farm Building Code.

OBJECTIVE

- To address public health and safety, related community issues and efficient construction through development of current and technically sound model building and fire codes; and to promote their use as the basis for uniform regulation throughout Canada

RECENT ACHIEVEMENTS

- Finalized guidelines for the application of Part 3 of the NBC to rehabilitation
- Initiated activities towards the development of a model code to regulate energy conservation in buildings
- Established the CCBFC to replace the Associate Committee on the National Building Code and the Associate Committee on the National Fire Code
- Delivered a cross-Canada seminar on major changes in the 1990 NBC

PLANS

- Evaluate the impact of the code-assessment framework and the move toward performance-based codes
- Analyze proposed changes to the national codes and distribute them for public review
- Publish commentaries on Parts 3, 5 and 9 of the NBC and an illustrated guide for the Canadian Housing Code
- Complete an impact study of the requirements for sprinklers in buildings
- Finalize recommendations from studies on audibility of fire alarm systems, and on outdoor storage of dangercus goods, including tires
- Establish a task group to develop requirements for egress by disabled persons

IRC's Canadian Codes Centre teams with industry and government to develop and publish the National Building Code, and four other model codes.

CODES TEAM

Alastair J.M. Aikman, B.Sc. (Eng.), M.A.Sc.
Denis Bergeron, B. Arch.
Raman B. Chauhan, B.Sc., M.Sc.
G. Adaire Chown, B. Arch.
Richard J. Desserud, B.Eng. (Centre Head)
Rachel Dussault, B.Sc.A., M.Sc.A., Ph.D.
Yvan E. Forgues, B.Sc.
John C. Haysom, B.A.Sc.
Dale A. Lutes, B.Sc., M.A.Sc.
Hal W. Nichol, B.Sc., D.P.A., M.A.
Igor Oleszkiewicz, M.Sc.
Alan M. de Taberer Phillips, B.Sc., M.E., Ph.D.
Ginette Rivard
Louise Thorne
Marc Walsh, B.A., B.A.Sc.

CONTACT

Canadian Codes Centre
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-9960
Fax: (613) 952-4040

IRC's Canadian Construction Materials Centre (CCMC) offers a national evaluation service for both novel construction products and products not covered under other programs. Evaluation is the objective assessment of a material, system, product or service for an intended purpose. The published results of these evaluations are used by building officials, designers and specifiers across Canada, thus giving companies a major advantage in marketing nationwide.

OBJECTIVE

- To support innovation, competitiveness, productivity, technology transfer and exportability in the construction industry through the evaluation of materials, products, systems and services

RECENT ACHIEVEMENTS

- Enhanced CCMC recognition by building officials in several provinces: Alberta will convert Standatas to CCMC evaluations and British Columbia has recognized CCMC evaluations as a tool for building officials
- Developed a proposal to provide a listing service for expanded polystyrene products already certified
- Began discussions with the International Council of Building Officials' Evaluation Service on a Memorandum of Understanding regarding common evaluation criteria
- Published Evaluation Listings, Vol. 1, NMS Division 8 (Doors and Windows), Fourth Edition
- Published Evaluation Listings, Vol. 2, NMS Divisions 1 to 7 and 9 to 16, Second Edition
- Published 60 new Evaluation Reports

PLANS

- Extend technical links to knowledge sources throughout Canada and abroad
- Develop CCMC's expertise in residential construction products into an authoritative source on product technology for other buildings
- Seek letters of agreement with U.S.-based evaluation services for long-term compatibility of evaluation criteria

EVALUATION TEAM

John F. Berndt, B.Eng. (Centre Head)
Marcel A. Brouzes
Al Caouette, B.C.E.
Luc F. Cecire, B.A.Sc.
Bruno DiLenardo, B.Eng.
Gerald Franche
Guy C. Gosselin, B.Sc., M.Sc., M.B.A.
Kate LeBlanc
Anne Marcil
Fadi E. Nabhan, B.Sc.
Gwen O'Brien
Ron C. Waters, B.C.E.

CONTACT

Canadian Construction Materials Centre
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Telephone: (613) 993-6189
Fax: (613) 952-0268

IRC's evaluation service promotes innovation by speeding product acceptance in the marketplace.

The Industry Liaison Branch is the technology transfer centre of the Institute for Research in Construction. It provides high-quality technical information, from IRC and international sources, to Canada's construction industry through technology networks, seminars, publications, and its literature collection.

Clients include the design and construction services communities, manufacturers and suppliers, and contractors and builders. The Branch encourages linkages with publishers, associations, and NRC's Industrial Research Assistance Program.

OBJECTIVES

- To encourage industry networks to disseminate new knowledge
- To deliver technical seminars in collaboration with the industry
- To publish technical information and to promote construction R&D
- To assist the construction industry to exploit IRC's information collection
- To facilitate industry access to IRC

RECENT ACHIEVEMENTS

- Delivered cross-Canada seminars on codes, standards and evaluation
- Supported Canadian Construction Research Board chapters
- Sponsored a seminar with the Royal Architectural Institute of Canada
- Assisted technology centres in Alberta and New Brunswick
- Distributed technology publications from European sources
- Published articles in trade magazines
- Developed a technical information package for trials on compact disc

PLANS

- Publish key information presented at the World Building Congress
- Deliver cross-Canada seminars on innovative lighting technologies
- Publish a manual on commissioning and facility management
- Develop information partnerships with engineering design associations
- Increase the construction industry's access to international technologies

TECHNOLOGY TRANSFER TEAM

Joan Allen
John Archer, B.A., B.Arch., M.A.
Arthur Bennett
Hélène Blondin
Ferrers Clark, B.Sc., M.Sc., Ph.D.
(Branch Head)
Louise Coutu, B.A.
Beverley Creighton
Joan Collins, B.A., B.A., M.L.S.
Anne-Marie Dorais, B.A.
David Finn, B.Eng., M.Eng.
Jim Gallagher, B.Sc.
Vicki Ganguli, B.Sc., M.L.S.
Christa Gaudert
Pierre Gratton, B.Eng.
Linda Hayes, B.A.
Bob Hewett, B.Sc.
Don Hobbs
Edgar L'Ecuyer
Gilles Ouellet, B.A., B.Theol.
Scott Mellon, B.Sc., M.L.S.
Bonnie Raymond
Madeleine Rousseau, B.Arch.
Luc Saint-Martin, B.Arch.
Dana Vanier, B.Eng., M.Eng.(Bldg.)

CONTACT

Client Services
Institute for Research in Construction
National Research Council of Canada
Ottawa, Ontario, Canada K1A 0R6
Tel: (613) 993-2607
Fax: (613) 954-5984

IRC's Industry Liaison Branch organized the 12th World Building Congress in Montréal, an international gathering of researchers and practitioners reporting the latest in building innovation.

DURABILITY OF ROADWAYS

Al-Hunaidi, M.O. 1991. Non-destructive profiling of pavement sites using the surface wave method: a case study. 44th Can. Geotechnical Conf., Calgary, September.

El Hussein, H.M., Svec, O.J. and K. Sepehr. 1992. Asphalt concrete low-temperature performance. Submitted to Int. Conf. on Localized Damage, Southampton, U.K., July.

Halim, A.E. and O.J. Svec. 1990. Influence of compaction techniques on the properties of asphalt pavements. Canadian Asphalt Technical Association Conference, November.

Svec, O.J. and A.O. Halim. 1991. Improving mechanical properties of asphalt concrete through a new compaction technique. Al-Azhar Engineering 2nd Int. Conf., Cairo, December.

Svec, O.J. 1992. Application of new compaction technique for deep lifts and large aggregate asphalt mixes. Submitted to 7th Int. Conf. on Asphalt Pavements, Nottingham, U.K., August.

Svec, O.J. and D. Eldred. 1992. New laboratory testing technique for asphalt concrete. TRB Annual Meeting, Washington, D.C., January.

FIRE SAFETY

Kim, A.K. 1991. Staying cool under fire. Glass Canada, 3(2):4-5.

Lie, T.T. and M. Chabot. 1990. A method to predict the fire resistance of circular concrete filled hollow steel columns. J. Fire Protection Eng. 2(4):111-126.

Lin, T.D., Lie, T.T., Burg, R.G. and R. McGrath. 1991. Fire resistance of eccentrically-loaded reinforced concrete columns, Research and Development Bulletin. Portland Cement Association, Skokie, IL, U.S.A.

Oleszkiewicz, I. 1991. Vertical separation of windows using spandrel walls and horizontal projections. Fire Technology, 27(4):334-340.

Sultan, M.A. 1991. Controlling fire spread in small buildings. Home Builder Magazine, 4(2):21.

Tamura, G.T. 1991. Stair pressurization systems for smoke control. ASHRAE Journal, 33(7):14-18.

Tsuchiya, Y. and J.F. Mathieu. 1991. Measuring degrees of combustibility using OSU apparatus and oxygen depletion principle. Fire Safety Journal, 17(4):291-299.

Yung, D. 1991. Small-scale compartment fire experiments with PMMA cribs. Fire Safety Journal, 17(4):310-313.

Yung, D. and J.R. Mehaffey. 1991. Fire resistance requirements for rubber-tire warehouses. Fire Technology, 27(2):100-112.

HEAT, AIR AND MOISTURE

Ascough, M.R., Bomberg, M.T. and M.K. Kumaran. 1991. The influence of environmental factors on thermal resistance of rigid polyurethane foams. Proc. Polyurethane World Congress 1991, pp. 399-407.

Bomberg, M.T. and M.K. Kumaran. 1991. Evaluation of long-term thermal performance of cellular plastics revisited. Insulation Materials: Testing and Application, 2nd Volume, ASTM Special Technical Publication 1116, pp. 123-141.

Bomberg, M.T., Kumaran, M.K. and M.R. Ascough. 1991. Effect of time and temperature on R-value of rigid polyurethane foam insulation manufactured with alternative blowing agents. Journal of Thermal Insulation, 14:241-267.

Elmahdy, A.H. 1991. High performance windows. Proc. 1st Annual Conf., Association Québec Solaire, Feb. 1991.

Elmahdy, A.H. 1992. Warm edge technology - The cold facts on a hot issue. Presented at the Winter Meeting of the Insulating Glass Manufacturers Association of Canada, Jan. 1992.

Goss, W.P., Elmahdy, A.H. and R.P. Bowen. 1991. Calibration transfer standards for fenestration systems. Site Heat Flux Measurements in Buildings Proceedings. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hamphire, Special Report 91-3.

Kumaran, M.K., Mitalas, G.P. and M.T. Bomberg. 1991. Chapter 1: Fundamentals of moisture transport and storage in building materials. ASTM Manual on Moisture in Buildings.

Mitalas, G.P. and M.K. Kumaran. 1991. Methods to calculate gas diffusion coefficients of cellular plastic insulation from experimental data on gas absorption. Journal of Thermal Insulation. 14:342-357.

Poirier, G.F., Brown, W.C. and A. Baskaran. 1992. Pressure equalization and the control of rainwater penetration. Proc. 6th Conf. on Building Science and Technology, March 5-6, Toronto, pp. 46-65.

Swinton, M.C., Brown, W.C. and G.A. Chown. 1990. Controlling the transfer of heat, air and moisture through the building envelope. Building Science Insight '90, Small Buildings: Technology in Transition. IRC/NRCC, pp. 17-31.

INFRASTRUCTURE FOR COLD CLIMATES

Chambers, D.A., Baker, T.H.W. and L.E. Goodrich. 1991. Foundation methods case study, Alert, N.W.T., Canada. Proc. 3rd Int. Symp. on Cold Region Development, Edmonton, June, p. 140.

Goodrich, L.E. 1991. Variable conductivity trafficked surface for permafrost regions (patent application).

White, T.L. and L.E. Goodrich. 1991. Evaluation of the potential of lightweight aggregate for use as thermal insulation in road embankments. Proc. 3rd Int. Symp. on Cold Region Development, Edmonton, June, p. 98.

LIGHTING

Ouellette, M.J. 1990. Spectral banding or iridescence with anodized aluminum reflectors. Conference Record of the 1990 IEEE Industry Applications Society Annual Meeting, Seattle, Washington, Part II, pp. 2015-2019.

Ouellette, M.J., Arseneau, R., Siminovitch, M. and S. Treado. 1991. New program for investigation of performance of compact fluorescent systems. Proc. Annual Conference of IEEE Industry Applications Soc., Sept 28-Oct 4, Dearborn, Michigan, pp. 1895-1897.

Rea, M.S. and M.J. Ouellette. 1991. Relative visual performance: A basis for application. Lighting Research & Technology, 23(3):135-144.

Tiller, D.K. 1990. Towards a deeper understanding of the phychological aspects of lighting. Journal of the Illuminating Engineering Society, 19:59-65.

Tiller, D.K., Ouellette, M.J. and I.C. Pasini. 1991. A method for predicting the economic consequences of changes in visibility. Proc. CIE 22nd Session, 2-11 July 1991, Melbourne, Australia.

MATERIALS

Parok, R.M., Dutt, O., Delgado, A.H. and M.N. Mech. 1990. Characterization of ethylene-propylene diene monomer (EPDM) roofing membranes using thermogravimetry and dynamic mechanical analysis. Thermochimica Acta, 182:303-317.

Feldman, R.F. and J.J. Beaudoin. 1991. Pretreatment of hardened hydrated cement pastes for mercury intrusion measurements. Cement and Concrete Research, 21(2/3):297-308.

Ping, Xie, Beaudoin, J.J. and R.J. Brousseau. 1991. Effect of aggregate size on transition zone properties at the portland cement paste interface. Cement and Concrete Research, 21:999-1005.

Ramachandran, V.S., Beaudoin, J.J. and R.M. Paroli. 1991. The effect of nitrobenzoic and aminobenzoic acids on the hydration of tricalcium silicate: a conduction calorimetric study. Thermochimica Acta, 190:325-333.

Litvan, G.G. 1990. Performance of parking garage decks constructed with epoxy-coated reinforcing steel. Proc. 5th Int. Conf. on Durability of Building Materials and Components, Brighton, U.K., Nov. 1990, 421-432.

Dutt, O., Paroli, R.M., Mailvaganam, N.P. and R.G. Turenne. 1991. Glass transitions in polymeric roofing membrane. 3rd. Int. Symposium on Roofing Technology, Montreal, April 1991, 495-501.

Mailvaganam, N.P. 1991. The repair and protection of concrete structures. Vol. 1-3. CRC Press, Boca Raton, FL.

Grattan-Bellew, P.E. 1991. Alcali-reaction. Resume des recherches presentees a la 8e conference internationale, Kyoto, Japon, Ciments, Betons, Platres, Chaux, 791-4/91:253-261.

ROOM ACOUSTICS

Bradley, J.S. 1991. A comparison of three classical concert halls. J. Acoust. Soc. Am., 89:1176-1192.

Bradley, J.S. 1991. Some further investigations of the seat dip effect. J. Acoust. Soc. Am., 90(1):324-333.

Bradley, J.S. 1991. Subjective disturbance of outdoor air-conditioner noise. Presented at Inter-Noise '91, Sydney, Australia, pp. 887-890.

Bradley, J.S. 1992. Predicting theatre chair absorption from reverberation chamber tests. J. Acoust. Soc. Am., 91(2).

Chu, W.T. 1990. Impulse response and reverberation decay measurements using a periodic pseudo-random sequence. Applied Acoustics, 29:193-205.

Chu, W.T. 1991. Impedance tube measurements - A comparative study of current practices. Noise Control Engineering Journal, 37(1):37-44.

Quirt, J.D. 1991. Sound emission from residential ventilation fans. Presented at Inter-Noise '91, Sydney, Australia, pp. 79-82.

SOUND TRANSMISSION

Halliwell, R.E. and J.D. Quirt. 1991. Controlling interoffice sound transmission through a suspended ceiling. J. Acoust. Soc. Am., 90(3):1146-1153.

Warnock, A.C.C. 1991. Sound transmission through two kinds of porous concrete blocks with attached drywall. Presented at Inter-Noise '91, Sydney, Australia, pp. 267-270.

Warnock, A.C.C. 1991. Sound transmission through concrete blocks with attached drywall. J. Acoust. Soc. Am., 90(3):1454-1463.

Warnock, A.C.C. and M.J. Morin. 1990. An evaluation of some procedures to control plumbing noise in lightweight construction. Canadian Acoustical Association, Montréal, 4-5 October 1990; also oral presentation, San Diego meeting of Acoustical Society of America, November 1990.

Warnock, A.C.C. and J.D. Quirt. 1991. Chapter 31: Airborne sound insulation. Handbook of Acoustical Measurements and Noise Control, Cyril M. Harris (ed.), McGraw-Hill, New York. pp. 31.1-31.31.

Warnock, A.C.C. and J.D. Quirt. 1991. Chapter 33: Noise control in buildings. Handbook of Acoustical Measurements and Noise Control, Cyril M. Harris (ed.), McGraw-Hill, New York. pp. 33.1-33.41.

STRUCTURES

Al-Hunaidi, M.O. and J.H. Rainer 1991. Remedial measures for traffic-induced vibrations at a residential site. Part 1: Field tests. Canadian Acoustics, 19(1):3-13.

Al-Hunaidi, M.O. and J.H. Rainer. 1991. Remedial measures for traffic-induced vibrations at a residential site. Part 2: FEM simulations. Canadian Acoustics, 19(2):11-20.

Allen, D.E. 1991. Limit states criteria for the structural evaluation of existing buildings. Canadian Journal of Civil Engineering, 18(6):995-1004.

Cao, Y.L. and K.T. Law. 1992. Energy dissipation and dynamic behaviour of clay under cyclic loading. Canadian Geotechnical Journal, 29(1).

Rainer, J.H., Dalgliesh, W.A. and D.E. Allen. 1991. Structural rehabilitation of buildings. Treasury Board Conf. on Technology and Real Property in the 1990's, Ottawa, November.

Jablonski, A.M. and J.H. Rainer. 1991. Effect of seismic input on hydrodynamic forces acting on gravity dams. Proc. 6th Can. Conf. on Earthquake Engineering, Toronto, pp. 157-164.

Keller, H., Trestain, T.W.J. and A.H.P. Maurenbrecher. 1992. The durability of steel components in brick veneer/steel stud wall systems. Proc. 6th Conf. on Building Science and Technology, Toronto, pp. 83-104.

Taylor, D.A. 1991. Snow loads on roofs in British Columbia: Results of a survey. Proc. Annual Conf. CSCE, Vancouver, May 29-31, Vol. III, pp. 205-213.

VENTILATION AND AIR QUALITY

Said, M.N. 1991. An evaluation of a network smoke control model. ASHRAE Transactions 1991, 97(1).

Shaw, C.Y., Magee, R.J. and J. Rousseau. 1991. Overall and component airtightness values of a five-storey apartment building. ASHRAE Transactions 1991, 97(2):275-282.

Shaw, C.Y., Magee, R.J., Shirtliffe, C.J. and H. Unligil. 1991. Indoor air quality assessment in an office/library building. Part I, Test methods. ASHRAE Transactions 1991, 97(2).

Shaw, C.Y., Reardon, J.T., Said, M.N. and R.J. Magee. 1991. Airflow patterns in a five-storey apartment building. Proc. 12th AIVC Conference – Air Movement and Ventilation Control Within Buildings, Ottawa, pp. 359-374.

Tsuchiya, Y. and M. Kanabus-Kaminska. 1990. Volatile organic compounds in Canadian indoor air. NATO/CCMS Pilot Study on Indoor Air Quality, Report of meeting in Sainte Adele, Québec, Aug. 6-8, 1990.

MR. GEORGE SEADEN
Director General, has completed his three-year term as President of CIB, the International Council for Building Research, Studies and Documentation. He has been appointed to the Editorial Board of Construction Business Review (U.S.), and of Building Research and Information (U.K.), the international journal of research, development and demonstration.

DR. R.C. BIGGS
Director of Research, has been appointed Chair of the Canadian Engineering Accreditation Board for 1992-93.

J.K. RICHARDSON
Head of the National Fire Laboratory, was inducted as a Fellow of the Society of Fire Protection Engineers, in recognition of his achievements in fire research and engineering.

MR. G.T. TAMURA
a senior researcher in the National Fire Laboratory, received the 1992 Arthur B. Guise Bronze Medal from the Society of Fire Protection Engineers, for many years of achievement in smoke-control engineering.

DR. G.V. HADJISOPHOCLEOUS
a researcher in the National Fire Laboratory, has been appointed an adjunct professor at the University of New Brunswick.

DR. S.A. BARAKAT
Head of the Building Performance Laboratory, was elected Chairman of the International Energy Agency's Executive Committee for Energy Conservation in Buildings and Community Systems.

DR. A. BASKARAN
a researcher in the Building Performance Laboratory, has been appointed an honourary faculty member at the Centre for Building Studies at Concordia University.

DR. V.S. RAMACHANDRAN
Distinguished Research Officer in the Materials Laboratory, was appointed chief editor of the Journal of Materials in Civil Engineering, published by the American Society of Civil Engineers.

DR. M.T. BOMBERG
a senior researcher in the Building Performance Laboratory, was named editor of the Journal of Thermal Insulation. Dr. Bomberg's recent work on the evaluation of plastic insulations made with non-CFC blowing agents has been widely acclaimed.

DR. J.D. QUIRT
Head of the Acoustics Laboratory, was reappointed for a three-year term as Architectural Acoustics Editor of the Journal of the Acoustical Society of America.

DR. A.C.C. WARNOCK
a senior researcher in the Acoustics Laboratory, was reappointed as Chairman of ASTM Committee E-33, which is responsible for developing and publishing most North American building acoustics standards.

DR. J.J. BEAUDOIN
Head of the Materials Laboratory, was elected Chairman of the Cements Division of the American Ceramic Society.

MR. G.S. WALT
a senior advisor on codes and evaluation, received the 1992 CSA Award of Merit for his outstanding contributions to Canadian standards.

DRS. R.M. PAROLI AND D.K. TILLER
were the only two Canadian researchers invited to attend the CIB Young Researchers Conference in Paris in 1992.

Senior Staff of the Institute for Research in Construction

MANAGEMENT

DIRECTOR GENERAL
G. Seaden, B.A., B.Eng., M.Sc.

DIRECTOR, RESEARCH
R.C. Bigga, B.Sc., M.S., Ph.D.

CODES AND EVALUATION
R.P. Bowen, B.Sc.

INDUSTRY LIAISON
F.R.S. Clark, B.Sc., M.Sc., Ph.D.

MARKETING AND CONTRACTS
J.V. Nolen, B.Eng., M.B.A.

RESEARCH HEADS

ACOUSTICS
J.D. Quirt, B.Sc., Ph.D.

FIRE
J.K. Richardson, B.Sc., B.Eng.

INFRASTRUCTURE
J.H.L. Palmer, B.A.Sc., M.A.Sc., Ph.D.

MATERIALS
J.J. Beaudoin, B.Sc., M.Sc., Ph.D.

BUILDING PERFORMANCE
S.A. Barakat, B.Sc., M.Sc., Ph.D.

STRUCTURES
J.H. Rainer, B.A.Sc., M.S., Ph.D.

CANADIAN CODES CENTRE
R.J. Desserud, B.Eng.

CANADIAN CONSTRUCTION MATERIALS CENTRE
J.F. Berndt, B.Eng.